**A COMPARATIVE EVALUATION OF FLEXURAL STRENGTH OF THREE COMMERCIALLY AVAILABLE FLEXIBLE DENTURE BASE RESINS – AN IN VITRO STUDY**

*Dissertation submitted to*

**THE TAMILNADU Dr. M.G.R. MEDICAL UNIVERSITY**

**In partial fulfillment for the degree of**

**MASTER OF DENTAL SURGERY**

**BRANCH I**

**PROSTHODONTICS AND CROWN AND BRIDGE**

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# Urkund Analysis Result

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# INTRODUCTION

# INTRODUCTION

Polyamide denture base material can be an useful alternative to poly methyl methacrylate[1,2] in special circumstances where higher flexibility, higher resistance to flexural fatigue. The improved flexural properties of nylon denture base materials has promoted their usage in conditions like unyielding undercuts, tuberosities ,tori and bulging alveolar ridges[3,4]. Thus, polyamide denture base materials are used because of higher flexibility compared to the commonly used poly methyl methacrylate .

An increasing number of products are being marketed as a flexible denture base material. These thermoplastic materials are monomer free, nylon based flexible denture base materials .With the progress in technology and understanding of material, improvised nylon polyamides are finding applications in fabrication of removable partial dentures, small to medium sized complete dentures, temporisation for fixed partial dentures, fibre reinforced posts, preformed clasps for partial dentures, obturators, flexible trays for making impression, occlusal splints, appliances for speech therapy and sleep apnoea[5,6].

These flexible partial dentures provide adequate stability and retention with high aesthetic value. Thermoplastic materials allow movement that acts as stress breaker by itself, which in turn maintains the health of tissues and teeth alike. However, drawbacks seen with thermoplastic materials are that they are highly technique sensitive with colour instability and water sorption. Later, advances in the nylon based denture fabrication were done to improve their properties . The flexible nature of the denture base prevents the transmission of undue forces on the abutment

# AIM AND OBJECTIVES

# AIM AND OBJECTIVE

## AIM

The aim of this study was to use three different commercially available denture base materials to evaluate their flexural strength.

## OBJECTIVE

The objective of the study was to evaluate the flexural strength of three commercially available flexible denture base resins in the dimensions of 80 mm length, 15mm width and 3mm thickness rectangular blocks.

teeth and underlying tissues[7]. Flexure strength can be described as the strength of the bar supported at its ends under a static load.

Various tests were used to evaluate the mechanical properties of denture base materials like flexural strength, impact strength, hardness, ductility and malleability. This study is conducted to know the flexural strength of three commercially available nylon based flexible denture base materials.

# REVIEW OF LITERATURE

## REVIEW OF LITERATURE

In an in vitro study conducted by **Eystein Ruyter (1980)**[8] to evaluate the mechanical properties of the three different types of denture base materials.test was done by transverse bending tests at very minimum deformation rates. The factors assessed in this study were temperature, environment, cross-linking agent, glass transition temperature, and prepolymer powders molecular weight on the mechanical properties of the final polymers . Autopolymerized dough and pour-type resins were selected in this study,because of different quantities and types of cross-linking agents. The autopolymerized dough- and pour-type resins use benzoyl peroxide and tertiary aromatic amine initiator systems, except the two products Palapress and Palacast, which use another redox initiator system. Heat polymerizing resins with cross linking agent 1,4 BDMA and with EGDMA have same flexural properties and due to solvent crazing denture base polymers have weaker flexural strength when they tested in water compared to air.

**Donna L. Dixon, DM 1992**[8]**-** conducted a study to calculate a mean transverse strength values for different materials, with the presence and absence of reinforcement materials. Nine in ten specimens Lucitone resin specimens fractured when three-point load was applied. ANOVA and Duncan’s multiple range test was done. Fiber inclusion did not have any effect on the mean transverse strengths of the tested resins. Mean transverse strength is recorded more with Triad resin reinforced specimens when compared to non reinforced specimens.

In an in-vitro study conducted by **Vallittu PK (1999)** [9] to determine deflection, flexural strength, impact strength and flexural modulus of acrylic denture base polymer when woven glass fibres were used to reinforce them. Silanized or unsilanized woven glass fibres were used in the current study. Specimens were subjected to heating. The denture cure resin dough contains glass fibers and were heated. After incorporating glass fibres five types of specimens with four varied thickness were prepared. Flexural properties and impact strength were determined using three point bend test and impact test. Specimens which were reinforced with silanized glass fibre exhibited higher impact and flexural strength when compared to unreinforced specimens. So statistical analysis revealed significant differences, when thickness of the specimen increased with unsilanized glass fibres

In an in-vitro study was conducted by **Jacob John (2001)**[10] to evaluate the flexural strength of a commercially available, heat-polymerized acrylic denture base material could be improved through reinforcement with 3 types of fibres. similar dimensions of ten samples were prepared, of which each of the 4 experimental groups are divided, they are conventional acrylic resin and the same resin reinforced with glass, aramid, or nylon fibres. Three point bending test is performed to determine the flexural strength. one-way analysis of variance is done for the results. Reinforced specimens have higher flexural strength than compared to the conventional acrylic resin. Highest flexural strength is noted with specimens reinforced with glass fibres, followed by aramid and nylon. Within the limitations of this study, the flexural strength of heat-polymerized poly methyl methacrylate denture resin was improved after reinforcement with glass or aramid fibres**.**

In an in-vitro study conducted by **Frederico Augusto Peixoto (2002)**[11] to evaluate the effect of intrinsic pigmentation on the microwave-cured acrylic resin. Forty transverse strength specimens were fabricated in this study and they are divided into 5 groups. No fibres were added to control group which is Group 1 ,acrylic stain was added to GII and GIII in concentrations of 0.5 and 1.5% w/w, respectively; acrylic fibres were added to groups GIV and GV in concentrations of 0.5 and 1.5% w/w, respectively. All specimens were irradiated in a microwave oven with a cycle of three min at 360 watts, followed by four min resting, then three min at 810 watts.. Flasks were bench-cooled for 30 min at room temperature, followed by immersion in cold tap water for 30 min. After storage in distilled water at 37oC for 48 h, all specimens were tested for flexural strength in a testing machine. Mean and standard deviation for the flexural strength test were obtained in Group 11. No statistical differences were detected among the groups in one way ANOVA analysis. The addition of the acrylic fibers or the acrylic stain did not affect the transverse strength of the microwave-cured acrylic resin.

In an in-vitro study conducted by **Gianluca Zappini (2003)**[12] to determine the fracture toughness of denture base resins and to compare the results with impact strength measurements. Five high impact and two conventional denture base resins were selcted. Three series of 12 specimens were used for the Charpy impact test notch depth and 2 Izod impact tests notch depth. The maximum stress intensity factor and the work of fracture were measured for 8 specimens in a fracture toughness test**.** The results achieved by the different materials and the rankings varied, depending on which parameter was considered. Specimen geometry and testing configuration influenced the impact strength measurements. The fracture toughness method seems to be more suitable than impact strength measurements to demonstrate the effects of resin modifications. The differences between conventional and so-called “high-impact” denture base resins are more clearly demonstrated with fracture toughness measurements.

In an in-vitro study conducted by **Sung-Hun Kim (2004)**[13] to evaluate measure the impact strength of maxillary complete dentures fabricated with high-impact acrylic resin and the effect of woven E-glass fibre-reinforcement on the impact strength of the complete dentures. Pre impregnated woven E-glass fibres were used to reinforce 10 complete denture bases fabricated with a heat-polymerized high-impact acrylic resin. For control group Ten unreinforced complete dentures were included. Before testing All specimens were stored in water for 2 months. Falling-weight impact test is performed to measure the impact strength of the dentures. The impact strengths of both groups were compared by a repeated measures analysis of variance. To calculate the cumulative fracture probability as a function of impact strength the weibull distribution was applied. Statistically showed that impact strength of the high-impact acrylic complete denture was prominently increased by the addition of woven E-glass fiber . The impact strengths of maxillary complete dentures fabricated with high-impact acrylic resin increased by a factor greater than 2 when reinforced with woven E-glass fiber.

In an in-vitro study conducted by **Peter Pfeiffer(2005)[14]** to compare the flexural strength and flexural modulus of four hypoallergenic denture base materials with flexural strength/modulus of a polymethylmethacrylate heat-polymerizing acrylic resin. The following denture base resins were examined: Sinomer which is heat-polymerized modified methacrylate, Polyan which is thermoplastic modified methacrylate, Promysan which is thermoplastic, enterephthalate based, Microbase are microwave-polymerized, polyurethane-based, and Paladon 65 which is heat-polymerized methacrylate, control group were included in this study. Results showed that flexural strength of Microbase was significantly lower than Paladon . Flexural strength of Polyan , Promysan , and Sinomer did not differ significantly from the control group. Significantly lower flexural modulus was obtained from Sinomer compared to the poly methyl methacrylate, whereas the flexural modulus of Promysan was significantly higher than the Poly methyl methacrylate material. Microbase and Polyan exhibited flexural modulus similar to the PMMA material. The tested denture base materials fulfilled the requirements regarding flexural strength. With the exception of Sinomer, the tested denture base resins passed the requirements of flexural modulus. Flexural modulus of Promysan was significantly higher than the PMMA material. Microbase and Sinomer exhibited significantly lower flexural strength and flexural modulus, respectively, than PMMA.

**Meng TR, Latta MA. 2005[15]**-The purpose of this laboratory study was to determine the Izod impact strength, the flexural strength, the flexural modulus, and the yield distance for four premium denture resins. Bar specimens 86 x 11 x 3 mm of Lucitone 199, Fricke Hi-I, ProBase Hot, and Sledgehammer Maxipack were fabricated following the manufacturer's instructions for heat processing. Ten specimens from three lots of each material were made .Analysis of variance (ANOVA) and post-hoc Tukey's test were used for statistical comparison of each property. There were significant differences in the physical properties among the denture acrylics tested. Lucitone 199 demonstrated the highest impact strength, flexural strength, and yield distance . Lucitone 199 with an Izod exhibited statistically greater results than Fricki Hi-I, ProBase Hot, and Sledgehammer Maxipack. Fricki Hi- I with a yield distance was statically greater than ProBase Hot and Sledgehammer Maxipack. On statistical analysis ProBase Hot and Sledgehammer Maxipack yielded statistically similar results for all tests performed.

In an in-vitro study conducted by **Scandinavica[2011][16]** to evaluate the mechanical properties of injection mold thermoplastic denture base resins. Four injection molded thermoplastic resins in which two poly amides, one poly ethylene pteryphthalate, one poly carbonate were included. As a control group conventional heat polymerized poly methyl methacrylate, were used in this study. The flexural strength at the proportional limit, elastic modulus and the charpy impact strength of the denture base resins were measured .He concluded that all of the injection molded thermoplastic resins had significantly lower FS-PL, lower elastic moduli, and higher or similar impact strength compared to the conventional PMMA. The polyamide denture base resins had lower FS-PL and low elastic moduli, one of them possessed very high impact strength, and the other had low impact strength. The poly ethylene terephthalate denture base resins showed a moderately high FS-PL., moderate elastic modulus , and low impact strength. The poly carbonate denture base resins had a moderately high FS-PL, moderately high elastis modulus, and moderate impact strength.

**Pande Neelam Abhay( 2012)** [17] This study was to evaluate the impact strength and the flexural strength of four different flexible denture base materials with high impact polymethyl-methacrylate). Fourty samples are included ten for each group of flexible denture base materials named, De-flex , Lucitone FRS , Valplast , and Breflex in specially designed flask by injection moulded process. Twenty samples were made for control , Trevelon denture base materials) were prepared by compression moulded process, for each test. p value is determined by ANOVA test . t-value is determined by Unpaired t test Statistically, the Valplast impact strength was found to be the highest than all other groups and nearer to the control group. Whereas Bre-flex had the maximum flexural strength. The flexural strength of De-flex was lowest than all other groups and nearer to control group. The values were found to be statistically significant but clinically nonsignificant with the control . The overall results of the study showed that, maximum impact strength is obtained with valplast and lowest flexural strength is obtained with De flex, whereas maximum flexural strength and lowest impact strength is obtained with Bre flex.

In an in-vitro study conducted by **Shivani kohli[2013]**[18] to evaluate and compare flexural modulus and flexural strength of two commercially available nylon based flexible denture base materials. valplast and Lucitone FRS and injection molded SR ivocap poly methyl methacrylate denture base resins. A total of fifteen samples of each group[GROUP A,B,C] valplast ,Lucitone FRS,SR ivocap were prepared.all the samples were subjected to three point bending test on an instron universal testing machine to test the flexural strength and flexural modulus. Results were statistically analysed using SPSS version tweleve. The different in flexural modulus and flexural strength of all the three groups was statistically significant $P < 0.05$. Study concluded mean flexural modulus of Valplast was significantly lower than Lucitone FRS, indicating that Valplast was less rigid ,more flexible than Lucitone FRS, and hence more useful in conditions where flexibility in denture base is desired.SR ivo cap displayed flexural strength comparable with Lucitone FRS ,but less than valplast.

In an in-vitro study conducted by **Arun jai kumar[2015]** [19] performed whether the flexural strength of commercially available ,heat polymerized acrylic denture base material could be improved using reinforcements. A total of thirty specimens [65mm x 10 mm x 3mm]were fabricated. The specimens were divided in to three groups with ten specimen each they were further divided in to Group 1-conventional denture base resins, Group 2-High impact denture base resins, and Group 3-glass reinforced denture base resins. The specimens were loaded until failure on a three point bending test machine. Data were analysed by SPSS Software version 21 and the results were obtain .The overall study showed that, poly methyl methacrylate reinforced with glass fibres showed the highest flexural strength values this was followed by PMMA reinforced with butadiene styrene, and the least strength was observed in the conventional denture base resins.

**Nesreen El Mekawy (2015)**[20]**-** Conducted a study to compare the effect of hard and flexible acrylic resins on tooth supported and retained mandibular over denture using various abutment preparation methods. Eighteen patients were selected for the study with completely edentulous maxillary arch with opposing mandibular arch where only canines on either side are present. Digital forcemeter device was used to check the retention feature of flexible and hard acrylic resins after one day, a week and after a month, which revealed a significant difference. Mandibular over denture with long copings exhibited more retention when compared with mandibular over dentures retained using stud attachments. Mandibular over denture with copings with copings which were small exhibited least retention. Thermo-elastic acrylic resin fabricated mandibular over denture showed greater retention values in digital forcemeter than hard acrylic resin fabricated mandibular over denture

**Gopinath anne(2017)[21]** did an in vitro study to evaluate flexural strength of conventional and different types of reinforced heat cure acrylic resins. He determine a flexural strength of poly methyl methacrylate by the addition of 2% by weight glass fibres and reinforced resins with metal mesh reinforcement. The study conducted with conventional acrylic resins ,conventional acrylic resin reinforced with glass fibres and metal mesh .flexural strength is done with three point bending test and the results were analysed by one way analysis of variance. Results showed that ,specimens reinforced with metal mesh are the highest flexural strength followed by resins reinforced with glass fibres and least flexural strength is obtained with conventional poly methyl methacrylate acrylic resins

**Arunakumari(2017)**[22] did a study to evaluate and comparison of flexural strength of conventional Heat cures denture base polymers with nylon denture base polymers. Specimen taken for this study Acrylyn H, Asian Acrylate for conventional heat cure acrylic resins and flexident, valplast for flexible denture base resins were used in this study.. she concluded that nylon denture base materials had greater resistance to fracture than the conventional heat cure denture base materials.

A study was done by **Parlani(2018)** [23] where flexible denture base material were checked for their flexural modulus when they were placed in artificial saliva, water, denture cleansing solution and air for varied intervals of time. Three groups with thirty samples each were devised for the study. Each group was subjected to a study period of fifteen days, one month and two months. The results obtained were subjected to statistical analysis. Nylon denture base materials exhibit lower flexibility when kept in air and water for longer time. Flexural modulus of denture base resins increases initially in denture cleansing solution and artificial saliva but shows gradual decrease in one month following that there is no effect in flexural strength. Artificial saliva is found out to be the best storage medium for flexible denture base materials..

# MATERIALS AND METHODS

# MATERIALS AND METHODS

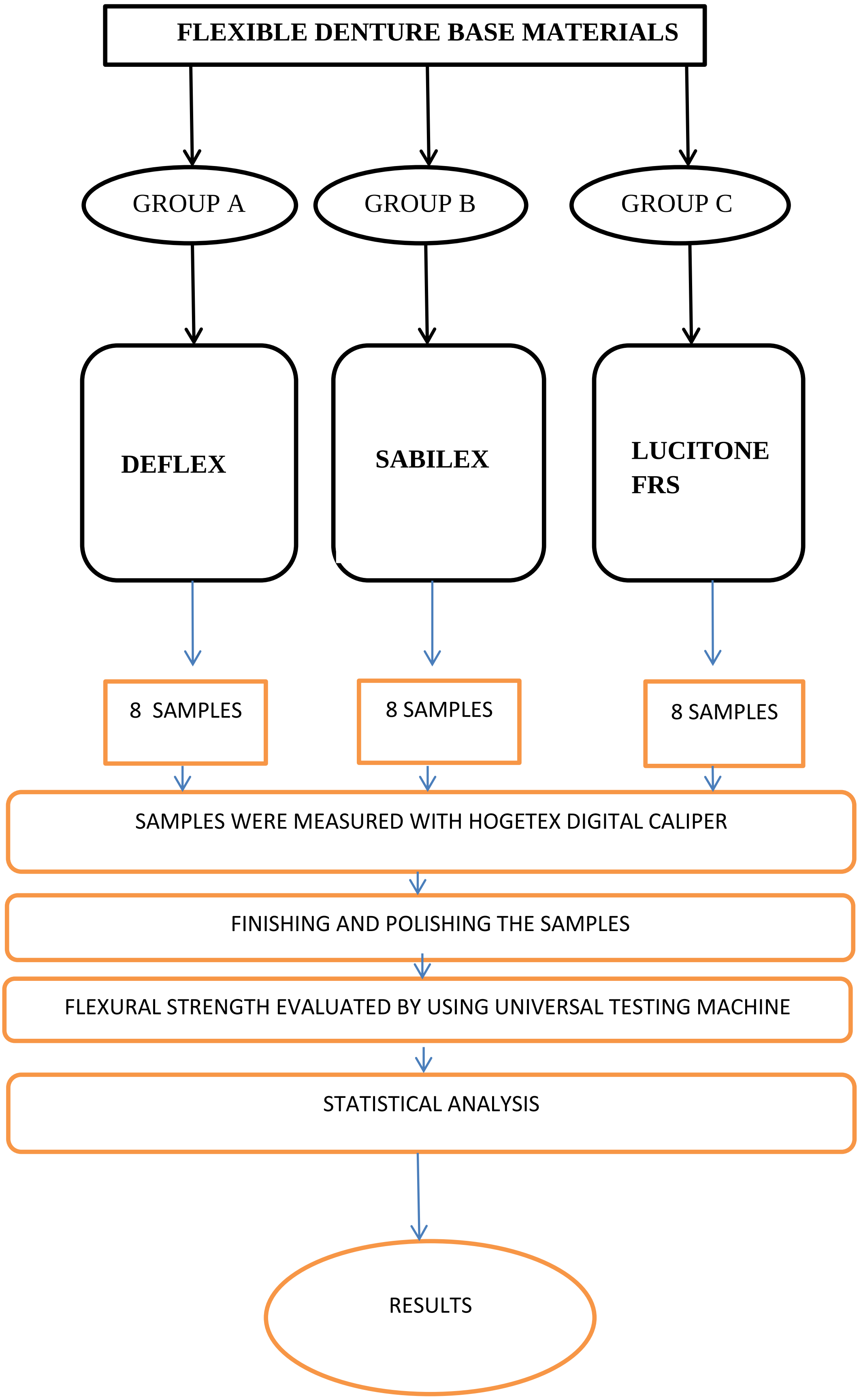
In this study flexural strength of GROUP A(Deflex), GROUP B(Sabilex), GROUP C( Lucitone FRS) denture base resins by using rectangular shape blocks of 80 mm length,15 mm width and 3mm thickness were used.

**MATERIALS USED IN THIS STUDY:**

**ARMAMENTARIUM AND EQUIPMENTS:**

| MATERIAL'S NAME | MANUFACTURER'S NAME |
|---|---|
| **FLEXIBLE DENTURE BASE MATERIAL**<br>1.Lucitone FRS | Dentsply Trubyte, U.S.A., |
| 2.Sabilex | NUXENSRL,<br>Buenos aires, ARGENTINA |
| 3.Deflex | Barcelona, SPAIN |
| MODELLING WAX | Hindusthan dental products<br>Hyderabad ,INDIA |
| HOGETEX DIGITAL CALIPER | |
| CARTRIDGE FURNACE<br>SUCCESS INJECTION SYSTEM | Dentsply, INDIA |
| UNIVERSAL TESTING MACHINE | Zwick roell, GERMANY |
| LIGHT LAMP | Philips |

**STUDY DESIGN:**



**STUDY METHODOLOGY:**

The study methodology followed was,

1. Wax pattern fabrication
2. Processing of the samples
3. Finishing and Polishing of the samples
4. Grouping of the samples
5. Flexural strength evaluation.

## PREPARATION OF WAX PATTERN:

Wax pattern was fabricated using modelling wax. Dimensions of the wax pattern are 80 mm in length, 15 mm width and 3 mm in thickness. Measurements were standardised using hogetex digital caliper.

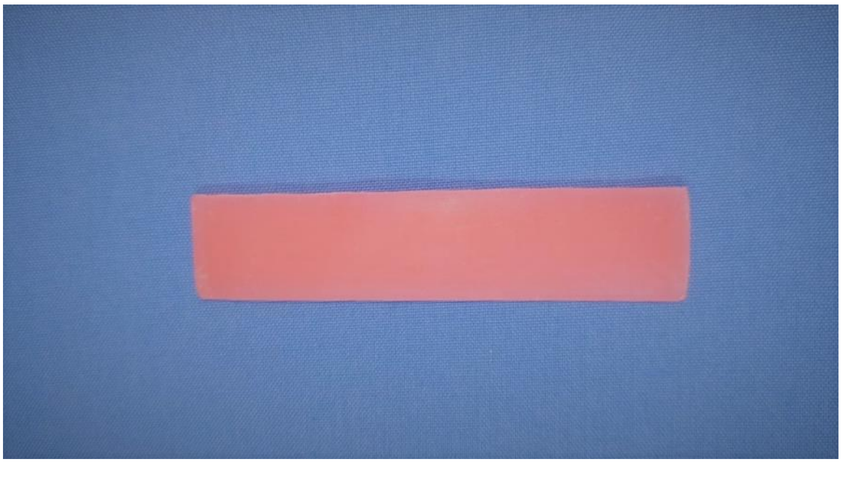


Figure 1: WAX PATTERN

Figure 2:    HOGETEX DIGITAL CALIPER

Figure 3:  LENGTH OF THE SAMPLE [80 MM]


Figure 4: WIDTH OF THE SAMPLE[15MM]

## PROCESSING AND FINISHING OF THE SAMPLES:

Injection moulding was carried out using a custom designed flask. Petroleum jelly was applied over the inner surface of the flask to facilitate for easy removal of the processed samples. Mixing dental stone according to manufacturer's instructions and poured in the flask.

After fabrication of the wax pattern by modelling wax to the above mentioned size, [Length 80 mm, Width 15 mm thickness 3 mm] wax pattern is kept in the flask. Modelling wax is used to fabricate sprue former which is then attached with the fabricated wax pattern.

PREPARATION OF LUCITONE FRS SAMPLES:[GROUP C]

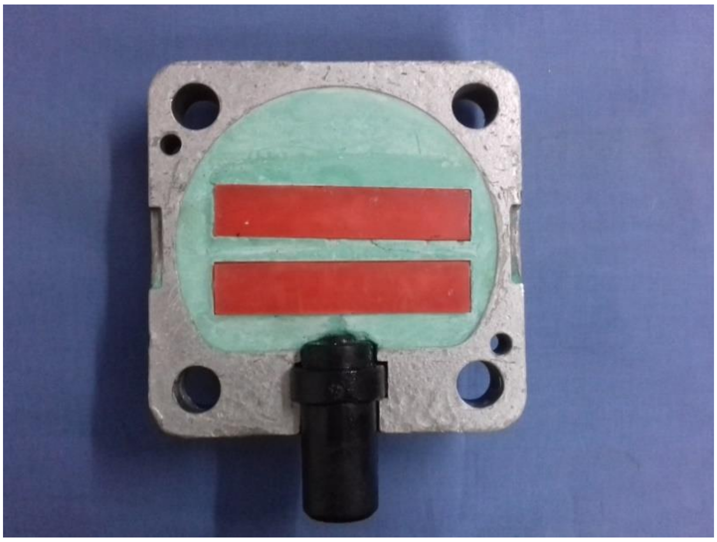


Figure 5: WAX PATTERN IN INJECTION MOULDING FLASK

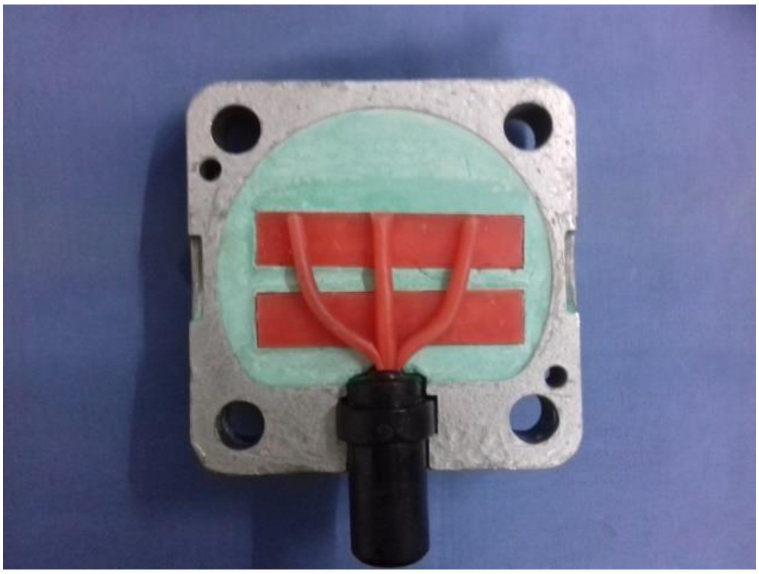


Figure 6(a) WAX SPRUES ATTACED IN WAX PATTERN

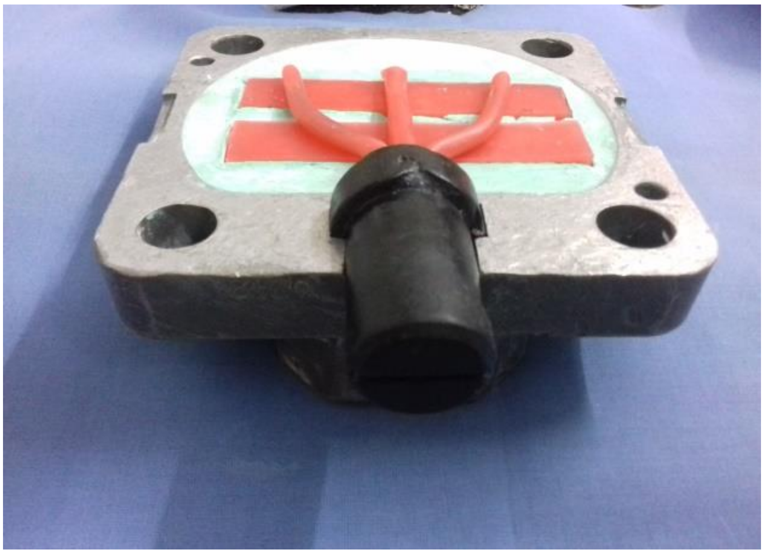


Figure 6(b) WAX SPRUES ATTACED IN WAX PATTERN

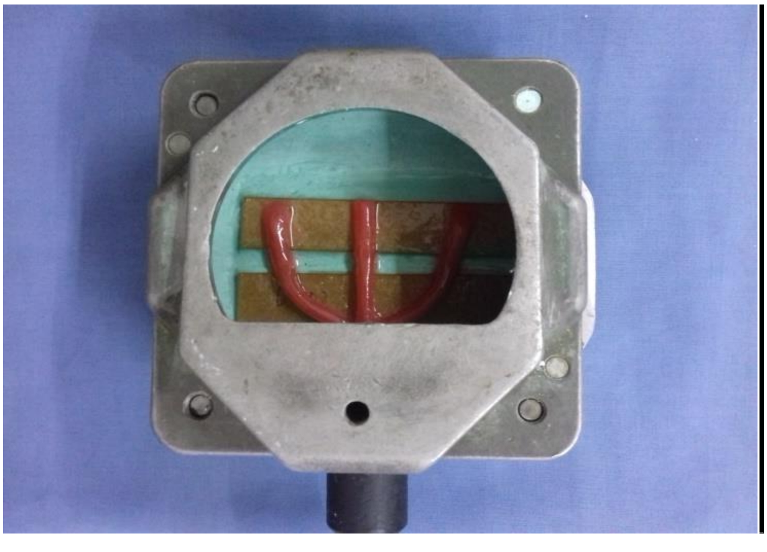


Figure 6(c) WAX SPRUES ATTACED IN WAX PATTERN

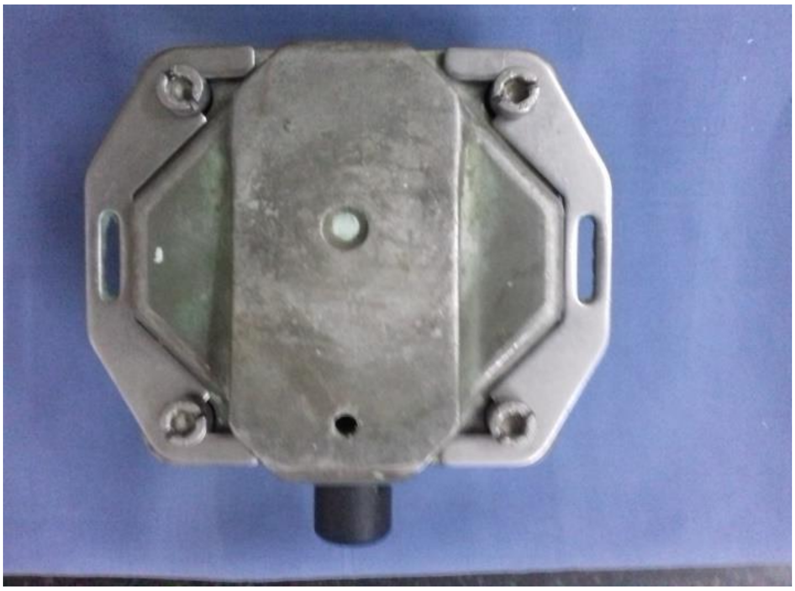


Figure 7: FLASK INVESTED WITH DENTAL STONE

After spruing was done the flask was kept for cooled to surrounding temperature and then invested using dental stone. Dewaxing was done and boiling water was used to remove wax left out in the mould space.

Ensure intimate metal contact of the margins of the flask. Petroleum jelly is painted over the mould and allowed to dry. The samples of each denture base material were fabricated according to the manufacturer’s instructions.

Figure 8: DEWAXING

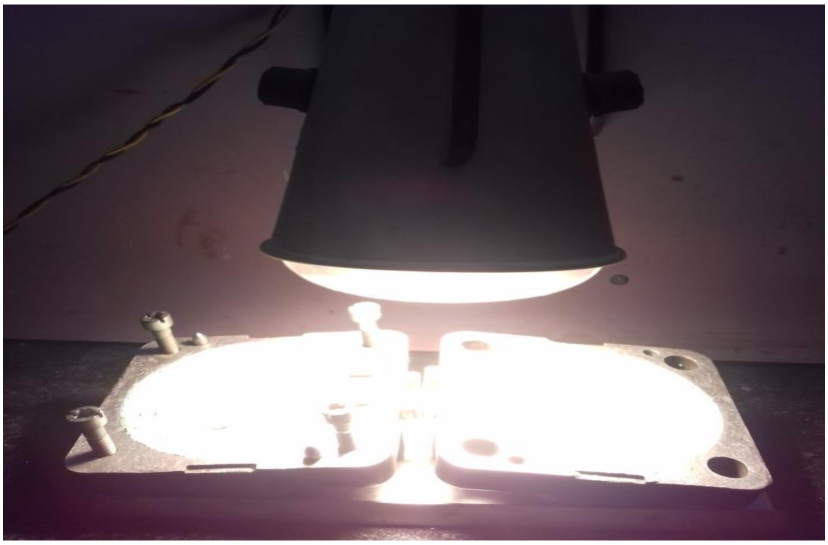


Figure 9(a): PREHEATING WITH LAMP LIGHT

Figure 9 (b): PRE HEATING

Separating medium was coated after setting of dental stone and cartridge was placed with space maintainer. The counter sink of the flask was assembled on the base part and the dental stone was poured.

Dewaxing was done and space maintainer for cartridge and wax pattern was carefully removed from the mould space. Separating medium was then applied and flask was cooled to room temperature.

**SUCCESS INJECTION SYSTEM:**


Figure 10(a): PRESSURE COMPRESSION UNIT


Figure 10 (b) : PRESSURE COMPRESSION UNIT

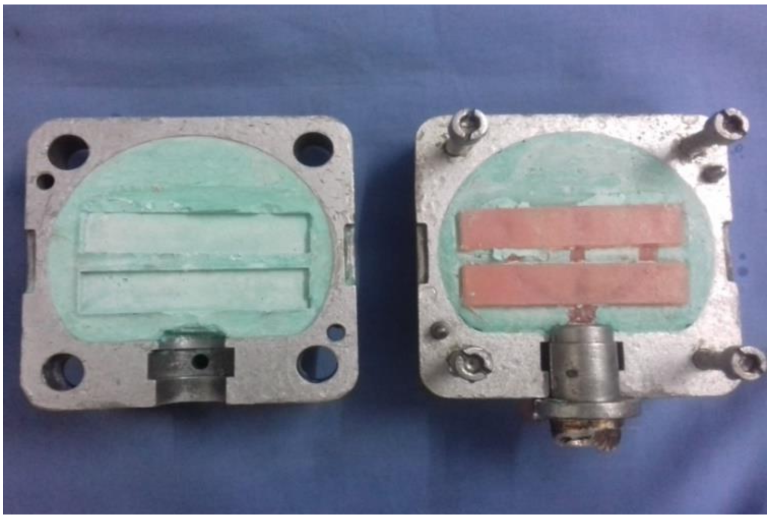


Figure 11: FLASK FOR INJECTION MOULDING SYSTEM


Figure 12: ELECTRIC CARTRIDGE FURNACE

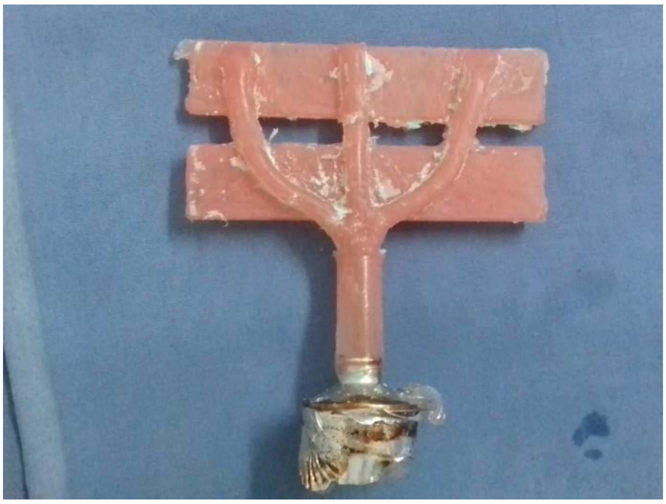


Figure 13 (a) :FABRICATED SAMPLES

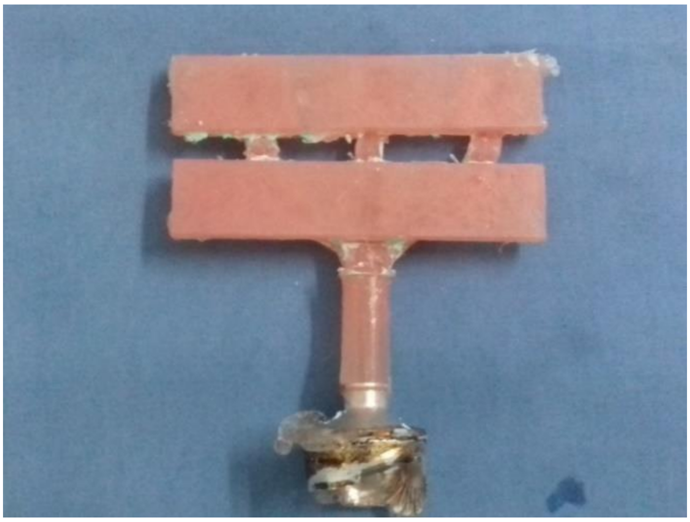


Figure 13(b) : FABRICATED SAMPLES

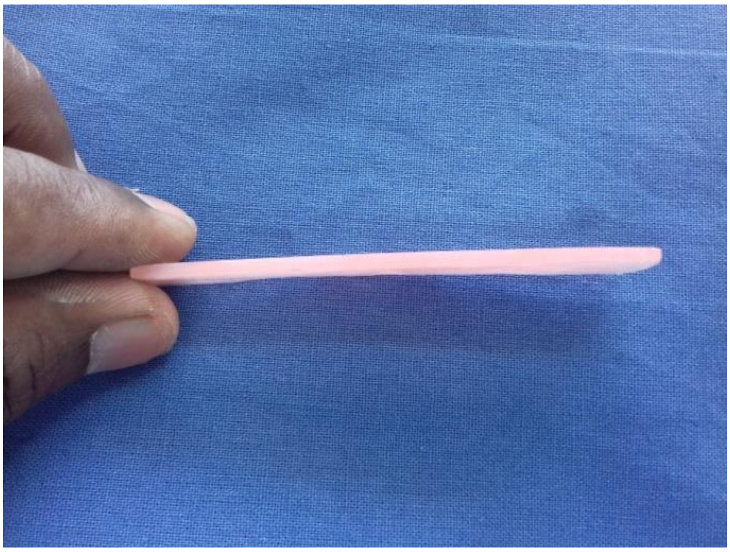


Figure 14 :SAMPLE WIDTH(3mm)

Figure 15 :POLISHED SAMPLE

Samples were polished using grit Sic paper and accuracy of the processed samples was verified using a digital caliper. Eight specimens were fabricated for each group and stored in water at room temperature.

Group C (Lucitone FRS) is supplied as a single component in a cartridge, which was placed in furnace and preheat treatment was done to 302 degree celcius .Stone moulds were opened and they were also heated to a uniform temperature of 70 degree celcius for 17 minutes. Preheating of the mould space was done to avoid premature cooling of the material which was injected under pressure. The metal injector was placed and the flask was assembled accordingly. Then entire assembly was placed in the success moulding unit and injection moulding was done.

Deflasking was done after bench cooling was done for five minutes. The samples were then removed from the investment and the sprues were cut. The specimens obtained were then finished and polished .

PREPARATION OF DEFLEX SAMPLES:[GROUP A]

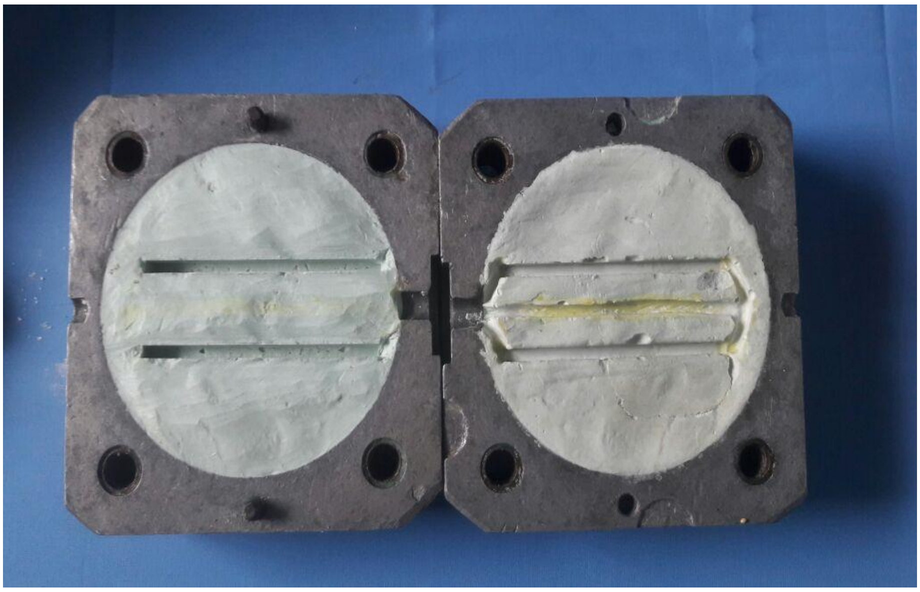


Figure 16 : DEWAXING DEFLEX SAMPLES

Figure 17 : FLASK

Figure 18(a)

Figure 18(b)

MANUAL COMPRESSION UNIT


Figure 19 FURNACE

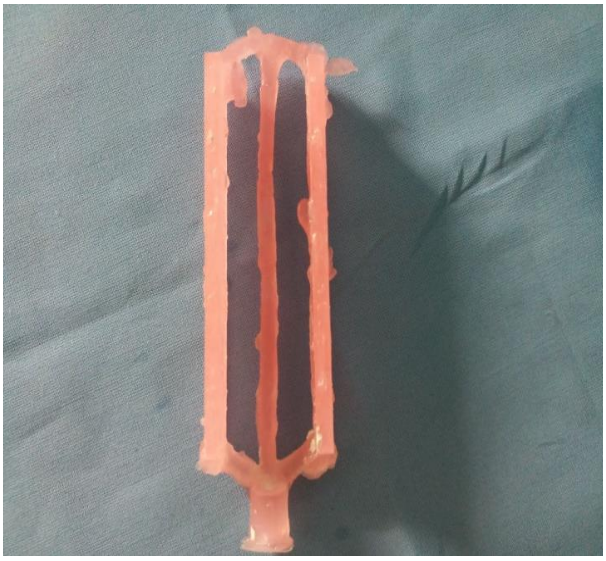


Figure 20   FABRICATED SAMPLE

Group A (Deflex) comes as a cartridge form. It is a one component system furnace and preheating treatment was done to 280 degree celcius. Stone moulds were also heated to achieve a temperature of 70 degree celcius for 15 minutes unlike Lucitone which needs 17 minutes. Preheating of the mould space was done to avoid premature hardening of Deflex. Continous pressure was given using manual compression unit. Then injection moulding was carried out as per necessary instructions.

Deflasking was carried out after adequate bench cooling.. The samples were divested from the mould and the sprues were trimmed. Finishing and polishing was adequately carried out.

PREPARATION OF SABILEX SAMPLES :[GROUP B]

Group B (sabilex) comes as a cartridge form. It is a one component system furnace and preheating treatment was done to 290 degree celcius. Stone moulds were also heated to achieve a temperature of 70 degree celcius for 15 minutes.

Preheating of the mould space was done to avoid premature hardening . Continuous pressure was applied using manual compression unit.

Then injection moulding was carried out as per necessary instructions. Deflasking was carried out after adequate bench cooling.. The samples were separated from the mould and the sprues were separated. Finishing and polishing was done.

## GROUPING OF THE SAMPLES:

Once the samples are fabricated the excess material was trimmed and polished. The samples were stored separately in distilled water for one week to simulate oral environment.

THREE DIFFERENT FLEXIBLE DENTURE BASE MATERIAS:

Figure 21(a) - GROUPNG OF THE SAMPLES

Then the samples are categorized according to their manufacturers name and samples were dried , grouped with each flexible denture base resins. They are divided and showed in three vertical rows, and its represents three different flexible denture base materials.

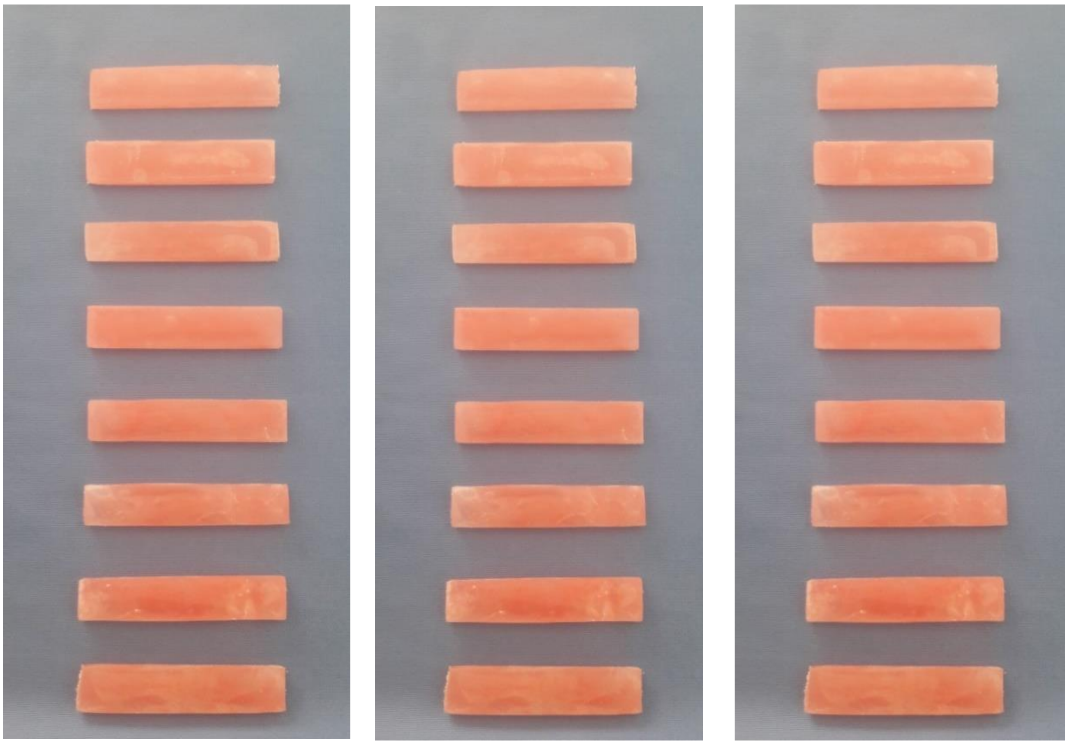


Figure 21(b) –INDIVIDUAL GROUPS

GROUP A GROUP B GROUP C

A total of 24 samples were made,it was divided in to three groups namely Group A,Group B ,Group C.

GROUP A : Lucitone FRS

GROUP B: Sabilex

GROUP C: Deflex

All the above groups made a same size of measurements like length of the sample is about 80 mm ,width of the sample is about 15 mm and thickness of the sample is about 3mm accordingly.

24 SAMPLES:

GROUP A : 8 samples,[ length 80 mm x width 15 mm x thickness 3mm]

GROUP B : 8 samples,[ length 80 mm x width 15 mm x thickness 3mm]

GROUP C : 8 samples,[length 80 mm x width 15 mm x thickness 3mm]

**UNIVERSAL TESTING MACHINE:**

**Figure 22: ZWICKROELL UNIVERSAL TESTING MACHINE**

sample is loses its stiffness. The values obtained were then tabulated and subjected to statistical analysis.

One way ANOVA was done to analyse the difference in flexural strength and inter group differences were analysed using Post hoc test.

Figure 23

**SAMPLE PLACED IN UNIVERSAL TESTING MACHINE**

The sample were then removed from the storage medium and dried and blotted to remove traces of liquid. Then the samples were tested using universal testing machine. Three point bending test was carried out to calculate the flexural strength of the prepared samples. The dimension of individual sample was pre programmed for computation. The distance between the two parallel rods of the universal testing machine are 60 mm in length.

Samples were placed between the two parallel rods and one vertical rod is placed in between the parallel rods for support. The sample must have a snug fit with the underlying parallel rods. When testing is performed with universal testing machine, the vertical rod is ensured to be at right angles to the sample. Vertical rod then moves downwards when the pressure is applied on the sample, till the

# RESULTS

## RESULTS:

The present study was designed with the objective of determining the flexural strength of different available flexible denture base resins. Totally, 24 samples were included in this study. They were divided in to three groups and each group further sub divided in to eight samples.

To determine the flexural strength, Kolmogorov-Smirnov and Shapiro-Wilk tests were used. Both the tests showed no significant differences and hence confirmed that the data obtained were normally distributed. The highest flexural strength was obtained with Group C [LUCITONE FRS] followed by Group A [DEFLEX] and least in Group B [SABILEX]. ANOVA and Post hoc test were used to determine the significance of the differences between the mean values and it depicts the difference in flexural strength between different groups.

**Table 2: Test for normality of the data**

| | Group | Kolmogorov-Smirnov | | | Shapiro-Wilk | | |
|---|---|---|---|---|---|---|---|
| | | Statistic | df | Sig. | Statistic | df | Sig. |
| Flexural strength | Group A | .207 | 8 | .200 | .933 | 8 | .547 |
| | Group B | .153 | 8 | .200 | .981 | 8 | .968 |
| | Group C | .142 | 8 | .200 | .930 | 8 | .516 |

df- degree of freedom

**Table 2** - Depicts test for normality of the data. Both the tests are insignificant, hence the data fall under normal distribution and parametric tests are used

**Table 3: Descriptive statistics among the groups to evaluate flexural strength**

| Groups | Mean | N | Std. Deviation | Minimum | Maximum | Range |
|---|---|---|---|---|---|---|
| Group A | 394.13 | 8 | 38.91 | 320 | 458 | 138 |
| Group B | 242.25 | 8 | 23.59 | 205 | 280 | 75 |
| Group C | 526.88 | 8 | 45.45 | 460 | 581 | 121 |
| Total | 387.75 | 24 | 123.97 | 205.00 | 581 | 376 |

Table 3 depicts descriptive statistics among the groups. Group C (526.88 ± 45.45) [LUCITONE FRS] had the higher mean score with minimum and maximum values 460 and 521 respectively with a range of 121, followed by Group A (394.13 ± 38.91) [DEFLEX] with minimum and maximum values 320 and 458 respectively with a range of 138 and least mean score in Group B (242.25 ± 23.59) [SABILEX] minimum and maximum values 205 and 280 respectively with a range of 75.

**Figure 23: Box plot graph of different groups**

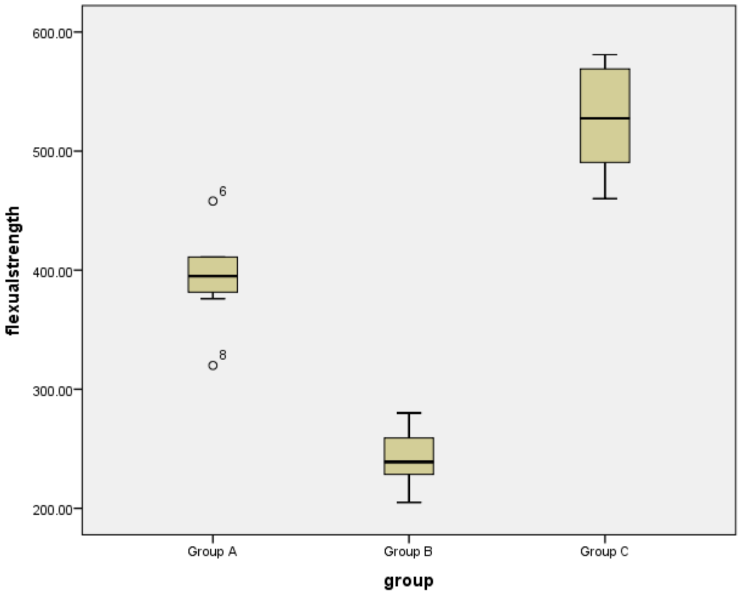



Figure 1 shows the median and outliers among different groups. Group C (527.2) [LUCITONE FRS]had the highest median score followed by Group A (395)[DEFLEX] and least by Group C (239) [LUCITONE FRS]. However, 2 outliers were found in Group A (320 and 458) [DEFLEX].

**Table 4: Difference in Flexural strength between different groups by**

**ANOVA TEST**

| | Sum of Squares | df | Mean Square | F | p-value |
|---|---|---|---|---|---|
| Between Groups | 324533.25 | 2 | 162266.63 | 117.7 | .001 |
| Within Groups | 28949.25 | 21 | 1378.53 | | |
| Total | 353482.5 | 23 | | | |

Table 4 depicts difference in Flexural strength between different groups is obtained. There is a statistically significant difference in flexural strength among the three different groups with sum of squares 324533.25 and mean square 162266.63 between the groups. (p <0.01).

**Figure 24: Difference in Flexural strength between different groups.**

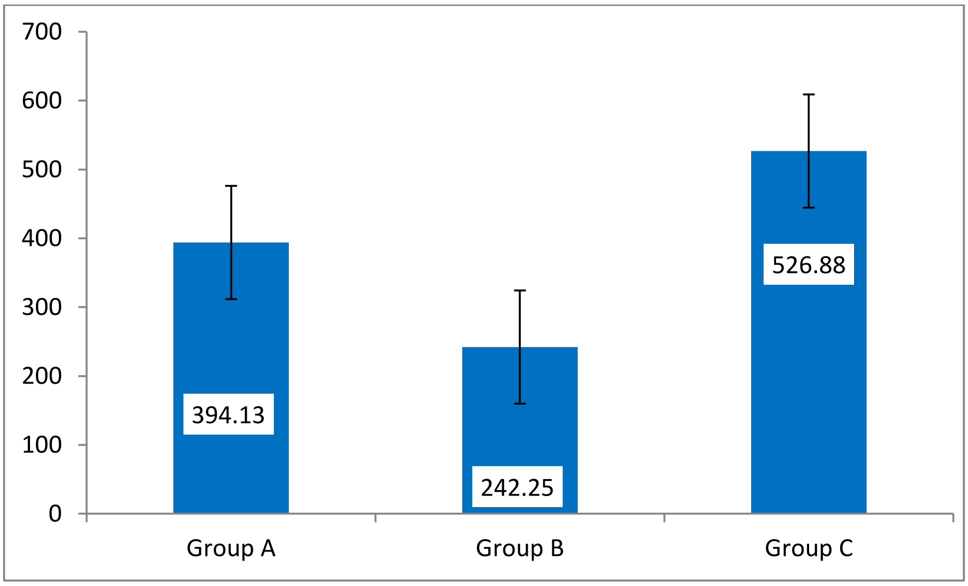



Figure 2 depicts difference in Flexural strength between different groups. Group C (526.88 ± 45.45) has the highest flexural strength followed by group A (394.13 ± 38.91) and least by group B (242.25 ± 23.59). The difference was found to be statistically significant. (p-value < 0.001)

**Table 5: Post hoc test to find the difference between the groups to evaluate flexural strength**

| (I) group | (J) group | Mean Difference (I-J) | Sig. p-value | 95% Confidence Interval | |
|---|---|---|---|---|---|
| | | | | Lower Bound | Upper Bound |
| Group A | Group B | 151.88 | .005 | 105.0823 | 198.6677 |
| | Group C | -132.75 | .001 | -179.5427 | -85.9573 |
| Group B | Group A | -151.88 | .004 | -198.6677 | -105.0823 |
| | Group C | -284.63 | .012 | -331.4177 | -237.8323 |
| Group C | Group A | 132.75 | .04 | 85.9573 | 179.5427 |
| | Group B | 284.63 | .001 | 237.8323 | 331.4177 |

Tukey's HSD

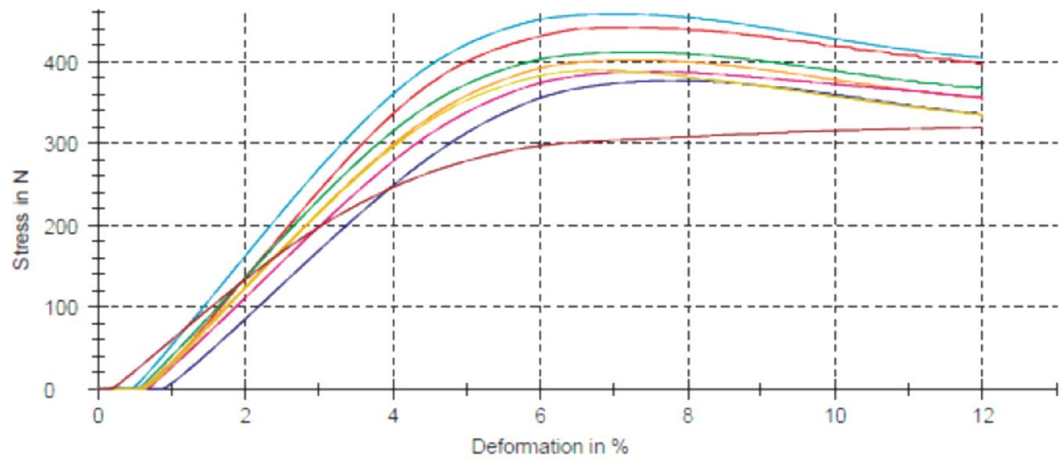
Table 5 depicts Post hoc test determined to find the difference between the groups. Group C has the highest flexural strength with mean difference between group A and Group B 132.75 and 284.63 respectively, followed by Group A with a mean difference of 151.88 between Group B. The differences are found to be highly statistically significant. (p-value < 0.001).

GROUP A

## Test results:

| No. | Specimen ID | $S_M$ N | $r_{max}$ % |
|---|---|---|---|
| 1 | GROUP A-1 | 441 | 12 |
| 2 | GROUP A-2 | 411 | 12 |
| 3 | GROUP A-3 | 376 | 12 |
| 4 | GROUP A-4 | 401 | 12 |
| 5 | GROUP A-5 | 387 | 12 |
| 6 | GROUP A-6 | 458 | 12 |
| 7 | GROUP A-7 | 389 | 12 |
| 8 | GROUP A-8 | 320 | 12 |

**Series graph:**

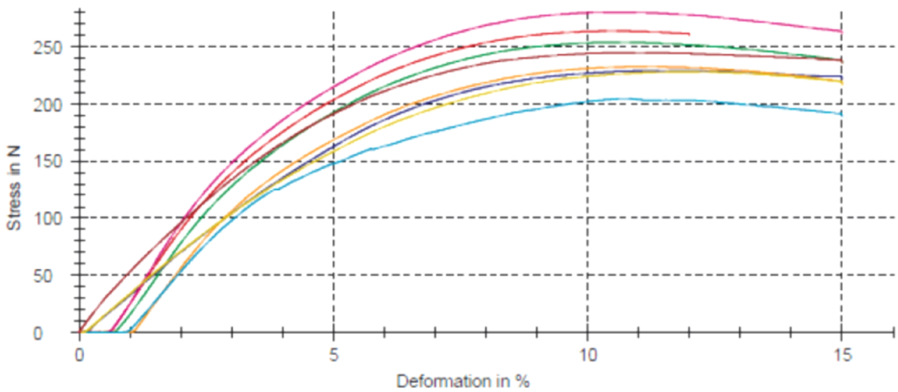


GROUP B

# Test results:

| No. | Specimen ID | $S_M$ N | $\varepsilon_{max}$ % |
|---|---|---|---|
| 1 | GROUP B-1 | 264 | 12 |
| 2 | GROUP B-2 | 254 | 15 |
| 3 | GROUP B-3 | 229 | 15 |
| 4 | GROUP B-4 | 233 | 15 |
| 5 | GROUP B-5 | 280 | 15 |
| 6 | GROUP B-6 | 205 | 15 |
| 7 | GROUP B-7 | 228 | 15 |
| 8 | GROUP B-8 | 245 | 15 |

**Series graph:**

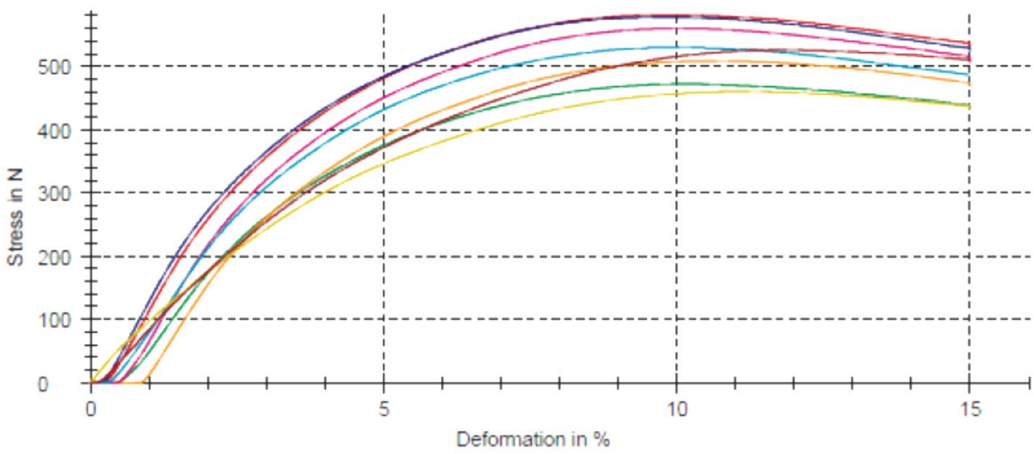


GROUP C

# Test results:

| No. | Specimen ID | $S_M$ N | $\varepsilon_{max}$ % |
|---|---|---|---|
| 1 | GROUP C-1 | 581 | 15 |
| 2 | GROUP C-2 | 472 | 15 |
| 3 | GROUP C-3 | 578 | 15 |
| 4 | GROUP C-4 | 509 | 15 |
| 5 | GROUP C-5 | 560 | 15 |
| 6 | GROUP C-6 | 530 | 15 |
| 7 | GROUP C-7 | 460 | 15 |
| 8 | GROUP C-8 | 525 | 15 |

**Series graph:**



**STATISTICAL INTERFERENCE:**

To test a flexural strength, Kolmogorov –Smirnov and Shapiro Wilk tests were performed to determine the normality of the data, Both the tests showed no significant differences and hence confirmed that the data obtained were normally distributed. Table 2 depicts the mean value, shows that highest mean value is obtained with Group C, followed by Group A and Group B. From the Table 3 since p value <0.001,it is inferred that there is highly significant difference in flexural strength among the three different groups.

Table 4, GROUP C[LUCITONE FRS] showed the highest flexural strength among the materials tested. The difference in mean values was found to be highly statistically significant between GROUP C [LUCITONE FRS]and GROUP A[DEFLEX] and, GROUP C[LUCITONE FRS] and GROUP B[SABILEX]. Also, there was a statistically significant difference in the mean between values of GROUP A[DEFLEX] and GROUP B[SABILEX].

# DISCUSSION

# DISSCUSSION

Poly methyl meth acrylate (PMMA)was introduced as a thermosetting, rigid, heat processed material in 1936.. Anusavice KJ [1] stated that PMMA has high internal energy, but absorbs water through imbibition. Dixon et al [8] did a study to incorporate carbon fibres in PMMA which increased porosity and caused imperfection of the surfaces which in turn deteriorated the final strength of the prosthesis. Because of the rigid nature of PMMA, it is not advisable to use it in areas which have severe undercuts, so polyamide materials can be used as an useful alternative in such cases. The results of the present study show that incorporation of nylon fibres with semi crystalline structure denture base resin material shows more flexural strength.

According to a study by Mathews E and Smith DC [24], when comparing the flexural strength of nylon materials to PMMA, the flexibility of nylon was superior to resist fracture under constant stress while in the present study it showed maximum flexural strength for Lucitone FRS than conventional heat cure denture base resins under constant stress.

Kausch et al [25] stated that, nylon material was processed in layers which further minimizes the chances of porosity. Higher strength is mandatory for use in oral cavity as denture fabricating material as it will be subjected to various forces within the oral cavity. Presence of nylon based polymer in GROUP C(Lucitone FRS) increases its cross linking which provides higher strength to the final prosthesis. Residual monomer is present in higher content in conventional acrylic resin which drastically reduces the strength of final prosthesis and may cause allergic reactions to some patients. Injection moulding technique eliminates residual monomer content to near zero.

Shivani Kohli [18] compared the flexural property of various nylon denture base materials like Valplast, Lucitone FRS and injection moulded SR Ivocap poly methyl methacrylate denture base resins. The result of the study showed flexural strength of Valplast was lower than the Lucitone FRS when compared to SR Ivocap (PMMA) denture base resins. In nylon load deflection curve increases as the strain increases at a particular point of stress and the elongation shows a rapid increase. This cold drawing behaviour is associated with the internal irregularity of nylon. PMMA is amorphous in structure, whereas nylon is a crystalline polymer. Thus in solid nylon, parallel packing of long chain molecules occur which is due to more attractive forces between the chains. The consequence is a more perfect parallel orientation of the molecules in the direction of elongation, which result in considerable increase in flexural strength. The mean flexural strength of GROUP C(Lucitone FRS )was (526.88+45.45MPa), GROUP A(Deflex) was (394.13+38.91) and Sabilex was( 242.25+23.59 MPa).The mean flexural strength of GROUP C(Lucitone FRS) was (526.88+45.45MPa) which is comparatively higher than the values obtained by Yunus N et al[26] .The values were given by Yunus N et al, GROUP C(Lucitone FRS) was 55.3+2.1 MPa. The difference in values may be due to dimensions of the sample(64x10x2.5mm) used in this study, whereas present study dimensions of the samples were (80x15x3mm)used.

Pande Neelam [17] stated that flexible denture base resin ,GROUP A ( Deflex) showed a lowest flexural strength when compared to the Trevalon denture base material (PMMA). The mean flexural strength of GROUP C (Lucitone FRS) was (135.63) and Deflex was about (120.66), which is comparatively lower than the present study. However , findings of this study are similar to the findings of our study where GROUP C (Lucitone FRS) showed the maximum flexural strength while GROUP A(Deflex) showed least strength.

The present study evaluated the flexural strength of three commercially available flexible denture base materials like GROUP A (Deflex) GROUP B (Sabilex) and GROUP C (Lucitone FRS). The samples were subjected to maximum deformation and they did not fracture. They were deflected beyond their maximum capacity so that flexural strength could be obtained at the maximal deformation point. The values obtained were statistically significant with p value <0.001. The values obtained were subjected to one way ANOVA and statistically significant difference were observed. According to the results GROUP C (Lucitone FRS)showed higher flexural strength when compared the GROUP A (Deflex) and GROUP B (Sabilex). Also flexural strength of GROUP A (Deflex) was midway between GROUP B and GROUP C. It implies GROUP B (Sabilex) has lower flexural strength among the three groups which were tested. Among the three different materials tested superior flexural strength was observed in Lucitone FRS.

The variation in the percentage of nylon incorporated in each of the material will have influence on the final flexural strength values obtained . The above mentioned are manufacturer dependant factors. Though injection moulding requires additional cost and equipment, the results which are obtained clinically justify the use of these materials and equipments to provide good patient centric treatment. But certain factors like mechanical and thermal stress interaction and presence of food can influence the outcome of this study. Due to inherent flexibility of the material it is widely used for removable partial dentures as interim prosthesis.

The material may have great potential for further development in future. After relating all the data inferred, the results of this study indicate that the GROUP C is more flexible than both GROUP A and GROUP B .Its flexural strength is higher than Deflex and Sabilex flexible denture base materials.

The applications of GROUP C(Lucitone FRS) flexible denture base material are limited in certain conditions like tuberosities, tori , unyielding under cuts excessive bulging of the alveolar processes particularly in the maxillary anterior region posing problems of retention as well as retention[28]. Also, effect of various internal and external factors like accuracy of the material, effect of micro organisms and water sorption need to be explored. Also it is not clinically correlated as the environment of the oral cavity similar in vitro so that further in vivo studies should be carried to verify these results. So the above mentioned factors can be considered as the limitations of the present study.

# CONCLUSION

# CONCLUSION

. The present study was undertaken to evaluate the flexural strength of three commercially available flexible denture base resins.

Within the limitation of the present study it can be concluded that, Group C (Lucitone FRS) had the maximum flexural strength followed by Group A (Deflex) and Group B. Group B (Sabilex) flexible denture base resin had the least flexural strength than other two flexible denture base resins.

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# SUMMARY

# SUMMARY

In this vitro study, the flexural strength of three flexible denture base resins GROUP A (Deflex), GROUP B(Sabilex), GROUP C (Lucitone FRS).These flexible denture base resin samples were 80 mm in length,15 mm in width and 3mm thickness . These samples were tested under universal testing machine to evaluate a flexural strength. Based on the test results and series graph, statistical evaluation was done by using ANOVA and Post hoc test. Depending upon the results, it was concluded that GROUP C (Lucitone FRS) had maximum flexural strength than GROUP A (Deflex) and GROUP B (Sabilex). GROUP B (Sabilex) had the least flexural strength.

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# GLOSSARY

| | |
|---|---|
| PMMA | Poly methyl methacrylate |
| EGDMA | Ethylene glycol dimethacrylate |
| BDMA | Butanediol dimethacrylate |
| UTI | Universal testing machine |
| HSD | Highly significant difference |